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Source Testing for Particulate Emissions From the Pathological Incinerator at Selkirk and District General Hospital, Selkirk, Manitoba

1986

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ABSTRACT

During 1986 two source emission surveys were conducted on the incinerator at Selkirk and District General Hospital, Selkirk, Manitoba. Previous testing in 1985 had revealed that the incinerator was in noncompliance with Manitoba Regulation 334/74, Section 3(1).

Following some changes to the operation of the unit, the first survey for 1986 indicated that the incinerator was still in noncompliance. During a follow-up survey, after further modifications and adjustments, the incinerator was deemed to be in compliance with the regulation. At that time, the average particulate concentration, when corrected to 12% CO_2, was 0.11 grams per dry standard* cubic metre (g/dscm).

* temperature 20°C, pressure 760 mm Hg

INTRODUCTION

A pathological incinerator is located at Selkirk and District General Hospital to completely destroy pathologicals, expired drugs, small pieces of sharp apparatus and (if wanted) general hospital wastes. Testing in 1985 revealed that the incinerator was in noncompliance with Manitoba Regulation 334/74, Section 3(1).

The incinerator manufacturer was then requested to take remedial steps to ensure compliance status. Two follow-up survey's (of 3 tests each) were conducted in 1986 to determine if the incinerator was now in compliance with the above mentioned regulation.

PROCESS DESCRIPTION

A Plibrico Model CAB-20-50P multiple chamber incinerator was tested for particulate emissions. Figure 1 depicts the incinerator as installed at Selkirk and District General Hospital. The design capacity was 20 cubic feet of Type I waste (normal rubbish) and 50 lbs. of Type IV waste (pathological) per cycle. The pathological, primary and after burner chambers were all heated by natural gas burners with a total heat input capacity of 1,025,000 BTU/hr. The incineration process was automatically controlled by a programmable operation cycle timer, which determined the sequence and duration of firing in the three chambers. The operational cycle was modified during the testing program to attain optimum combustion conditions while still meeting hospital requirements. See Table 1 for reference examples of the cycles during the testing. Drying, ignition and partial combustion of the waste occurred in the pathological and primary chambers. Air intake to both chambers was reduced to control the combustion rate and temperature. This prevented turbulent gases from transporting ash particles into the after burner chamber. Final combustion of gasified and partially combusted volatile components occurred in the after burner chamber, where air was supplied in excess of stoichiometric requirements to enhance combustion.

Various combustion products exit through a 12.6 m (41.2 ft.) steel stack. A ceramic liner was installed as an insulator. The stack had a continuous inside diameter of 30.5 cm (12 in.).

When the incinerator had cooled, ash was removed from the pathological and primary chambers.

The incinerator configuration for Test 1 was identical to that of the 1985 compliance tests. For Tests 2 and 3 the pathological chamber was sealed off with refractory bricks and the burner was turned off.

Normal procedure at Selkirk General Hospital was to incinerate pathologicals only (Type I waste was sent to a landfill site). For Tests 4 to 6 the incinerator was set up for normal rather than maximum load conditions ie. (1) the brick was removed that temporarily separated the pathological from the primary chamber, (2) the pathological burner was re-activated, (3) the primary burner was de-activated, (4) the afterburner preheat was increased to one hour and (5) only pathological wastes were incinerated.

During Test 4 low stack gas temperature and CO_2 content indicated that the combustion blower was supplying too much air for the pathological burner alone. The blower output was reduced prior to any further testing. Tests 5 and 6 proceeded without further adjustment or modification.

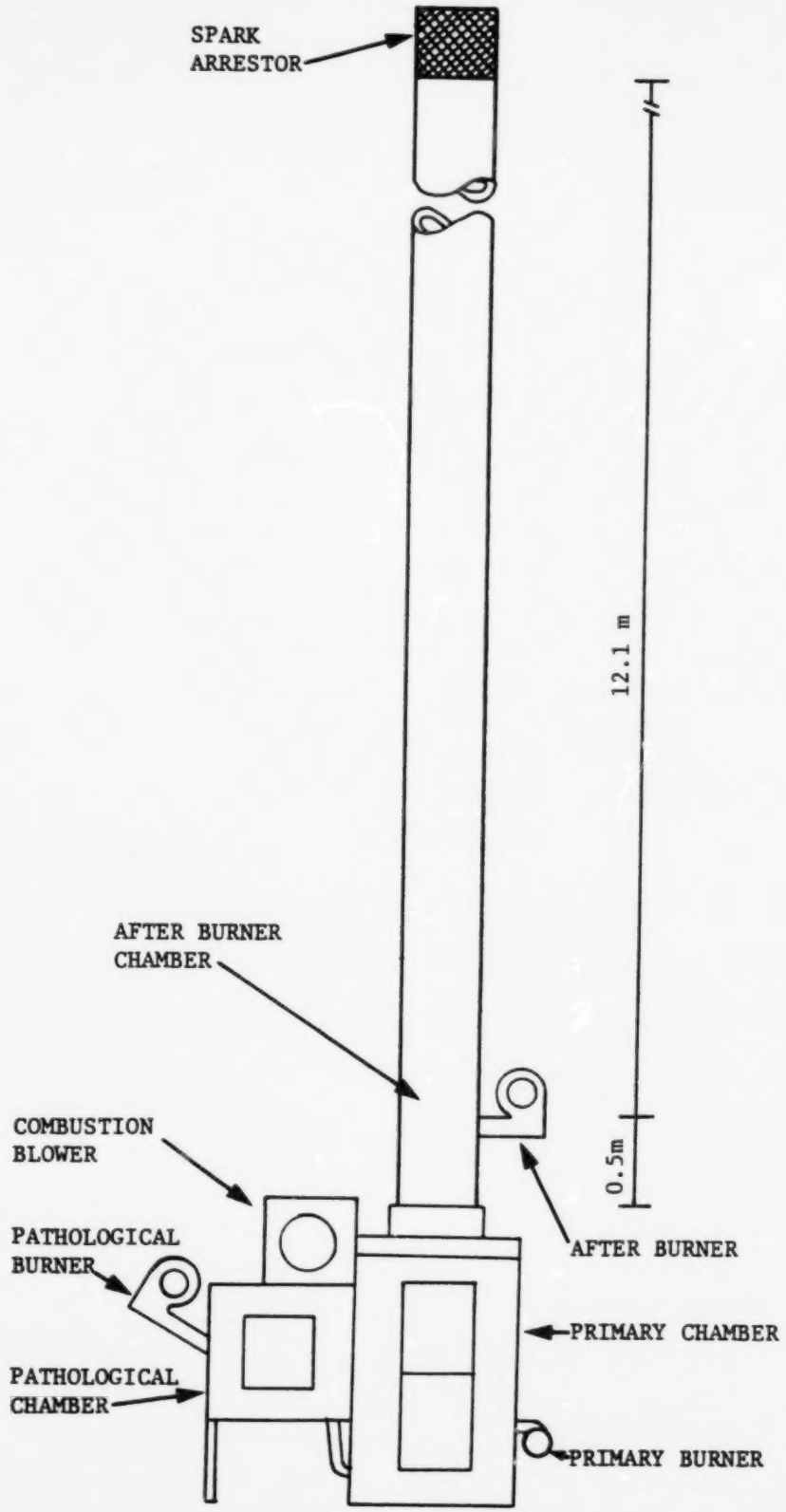


FIGURE 1. PLIBRICO CAB - 20 - 50 P INCINERATOR AS INSTALLED AT SELKIRK AND DISTRICT GENERAL HOSPITAL

TABLE 1: INCINERATOR OPERATIONAL CYCLE

ITEM	TEST 1	TEST 2-3	TEST 4-6
CYCLE INITIATED	8:00 AM*	8:00 AM*	8:00 AM*
AFTER BURNER ON	8:01 AM	8:01 AM	8:01 AM
COMBUSTION BLOWER ON	8:30 AM	8:30 AM	9:00 AM
PRIMARY BURNER ON	8:31 AM	8:31 AM	--
PATHOLOGICAL BURNER ON	8:31 AM	--	9:01 AM
PRIMARY BURNER OFF	8:46 AM	10:31 AM	--
PATHOLOGICAL BURNER OFF	9:31 AM	--	10:31 AM
AFTER BURNER OFF	12:31 PM	12:31 PM	12:31 PM
COMBUSTION BLOWER OFF	4:00 PM	4:00 PM	4:00 PM

* For comparison purposes only all cycles start at 8:00 AM

PROCESS SCHEDULE

Charging material for the 1986 emission tests was limited to 1) general hospital wastes (packaged in green garbage bags), 2) pathological wastes (packaged in red garbage bags) and 3) special wastes such as sharp surgical items, glass ampules and out of date drugs (packaged in sealed cardboard boxes). The charging schedule can be found in Table 2.

TABLE 2: INCINERATOR CHARGING SCHEDULE

TEST NUMBER & DATE	PRIMARY CHAMBER	PATHOLOGICAL CHAMBER
1 - May 13, 1986	80 lbs. (I)*	55 lbs. (IV)*
2 - May 15, 1986	25 lbs. (I) 63 lbs. (IV)	--**
3 - May 22, 1986	55 lbs. (I) 65 lbs. (IV)	--
4 - August 26, 1986	--	50 lbs. (IV)
5 - August 28, 1986	--	40 lbs. (IV)
6 - September 3, 1986	--	40 lbs. (IV)

*(I) refers to Type I waste (normal rubbish)

(IV) refers to Type IV waste (pathological)

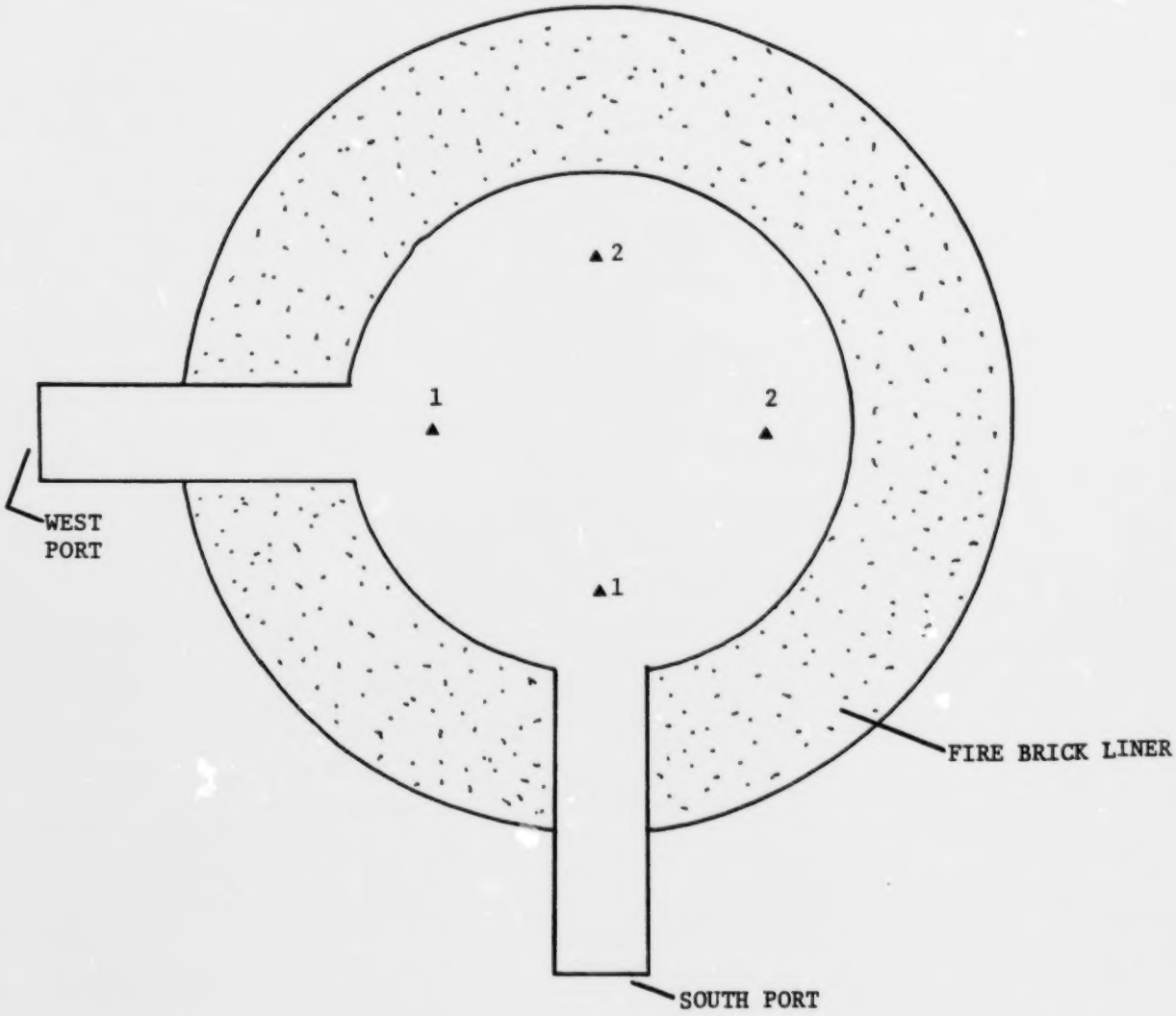
** -- indicates that the chamber was not loaded

TEST PROCEDURES

Sampling for Tests 1 to 3 was conducted through two ports located at right angles to each other (south and west) 3.7 m (12.0 ft.) above the after burner nozzle and 8.4 m (27.7 ft.) below the top of the stack. This corresponds to 11.1 and 25.4 duct diameters respectively of unrestricted flow before and after the sampling location. Two points were twice sampled along each traverse according to Environmental Protection Service (EPS) Method A specifications. The sample points, located 4.6 and 25.9 cm (1.8 and 10.2 in.) respectively from the inner stack wall are depicted on a cross section of the stack in Figure 2. Sampling intervals were five minutes per point.

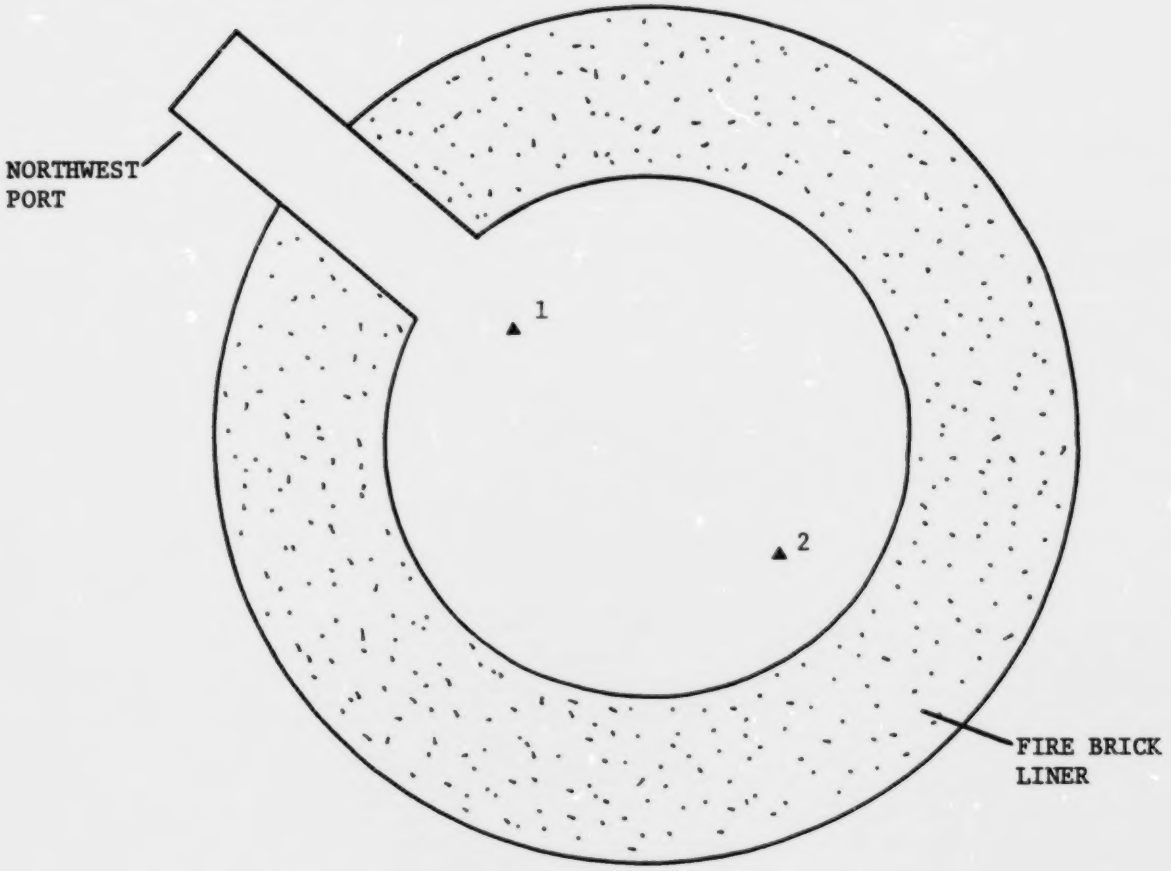
Sampling for Tests 4 to 6 was conducted through a single port 10.4 m (34.1 ft.) above the after burner nozzle and 1.7 m (5.5 ft.) below the top of the stack. This corresponds to 34.1 and 5.6 duct diameters respectively of unrestricted flow before and after the sampling location. Two points were sampled for 20 minutes each (in 5 minute intervals). The sample points, located 4.6 and 25.9 cm (1.8 and 10.2 in.) respectively from the inner stack wall are depicted on a cross section of the stack in Figure 3.

Source emission testing was conducted according to EPS Method E, with one exception. To eliminate metal fatigue caused by the high stack gas temperature, the probe was water cooled rather than electrically heated. Figure 4 illustrates the particulate stack sampling train. The sample was drawn into a 12.57 mm (0.495 in.)



▲ = SAMPLE POINT LOCATION

FIGURE 2. STACK CROSS SECTION DEPICTING SAMPLE POINTS FOR TESTS 1 to 3.



▲ = SAMPLE POINT LOCATION

FIGURE 3. STACK CROSS SECTION DEPICTING SAMPLE POINTS FOR TESTS 4 to 6.

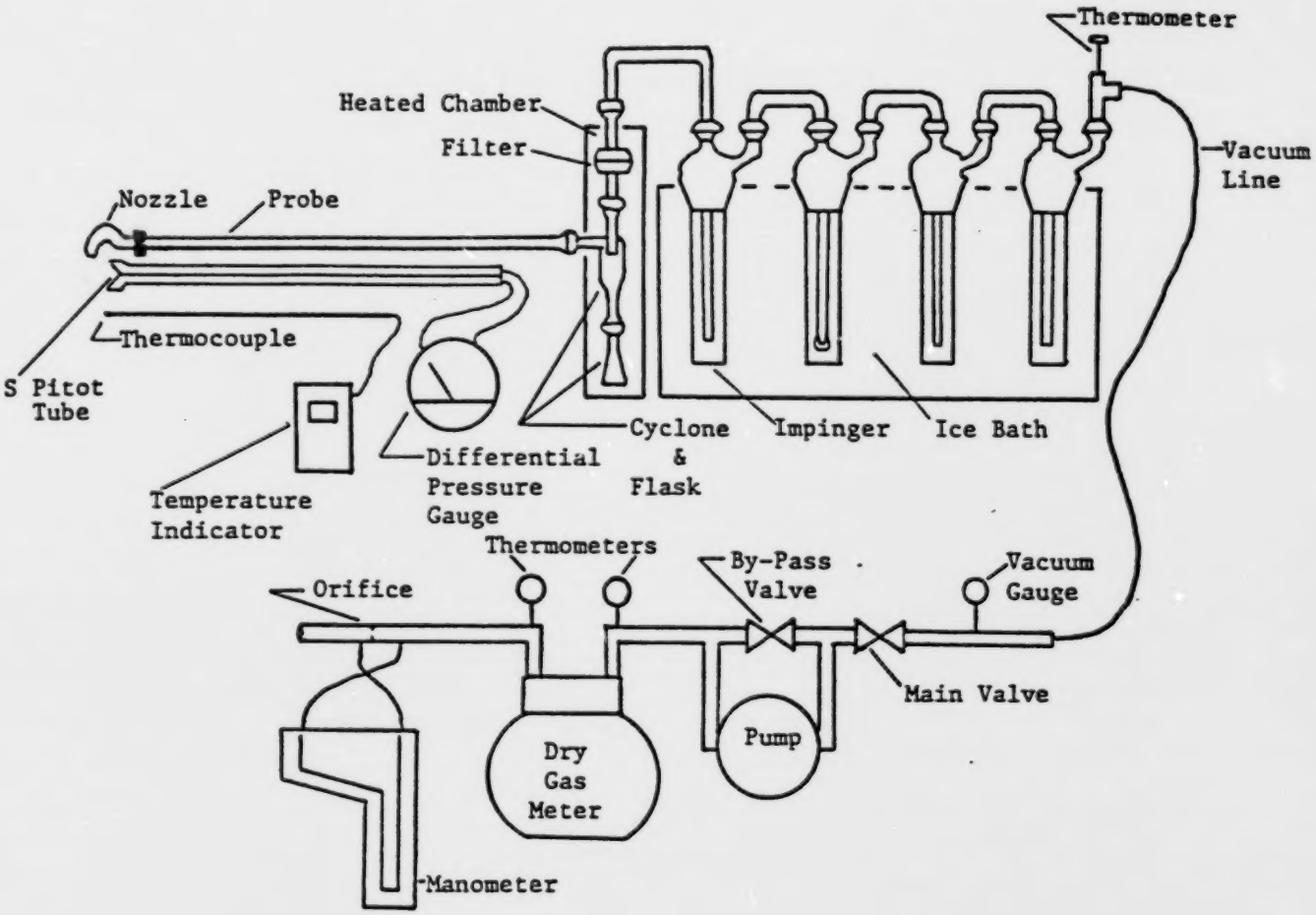


FIGURE 4. Particulate Stack Sampling Train

nozzle, through a stainless steel probe and into a miniature cyclone which removed particulate matter of greater than 10μ diameter. The sample was then passed through a Whatman 934 AH glass microfiber filter (supported by a porous fritted glass disc) which removed particulates of 0.3μ diameter and greater. Both the cyclone and the filter were heated to prevent moisture from condensing on the glassware. The sample was then passed through four 500 ml Greenburg-Smith impingers connected in series in an ice bath. The first, third and fourth impingers had modified straight tips while the second was of the standard design. The first and second impingers contained 100 ml of deionized water. The third impinger was initially empty while the fourth contained 200 grams of indicating silica gel to remove any remaining moisture from the gas sample.

A Bendix Series 4500 Isokinetic Stack Sampler was used to extract the samples from the stack. Gas velocity in the stack was measured with an S type pitot tube and a Dwyer Magnehelic Differential Pressure Gauge (range 0 to 0.25" H_2O, minor division 0.005" H_2O). Dry gas meter and pitot tube calibration data sheets are located in Appendix A. A Hays-Republic Model 621A Gas Analyzer was used to determine CO_2, O_2 and CO content of the stack gas for Tests 1 to 3. A Nova Analytical Systems Model 370 Portable Flue Gas Analyzer (ranges: CO_2 0-20%, O_2 0-25%, CO 0-2000 PPM and 0-4%) was used to analyze the stack gas for Tests 4 to 6. Stack temperature was measured by a K type thermocouple.

After sample recovery from the stack train, samples were submitted to the W. M. Ward Technical Services Laboratory for gravimetric analyses of particulates. As the nozzle was not water cooled (and therefore subject to metal fatigue) the particulate matter extracted from it was not included in the sample submitted to the lab.

The sampling team consisted of Kevin Reeve, Art Schultz and Barry Cowan.

RESULTS

During the testing program the incinerator was controlled by a programmable operational cycle timer. Modifications and adjustments were made during and/or following Tests 1, 3 and 4 in order to increase unit efficiency.

Important sampling parameters are summarized in Table 3. Source emission data are summarized in Table 4. Refer to Appendices B, C and D respectively for velocity profiles, field data sheets and laboratory analytical reports.

TABLE 3: SUMMARY OF SAMPLING PARAMETERS

TEST NUMBER	1	2	3
SAMPLING DATE	May 13/86	May 15/86	May 22/86
SAMPLING DURATION, min.	40	40	40
SAMPLE VOLUME AT METER CONDITIONS, m^3	0.8185	0.6808	0.9946
SAMPLE VOLUME AT STANDARD CONDITIONS, dscm*	0.7570	0.6434	0.6591
AVERAGE GAS METER TEMPERATURE, °C	32	27	36
ORIFICE PRESSURE DROP, mm H_2O	45.72	31.04	33.02
STACK STATIC PRESSURE, mm H_2O	-7.62	-7.62	-7.62
AVERAGE STACK GAS TEMPERATURE, °C	909	863	849
AVERAGE STACK GAS VELOCITY, m/s	11.9	9.5	9.4
ISOKINETIC FACTOR, %	100.7	104.0	102.5

*Standard Conditions are 20°C and 760 mm Hg

TABLE 3: (CONTINUED)

TEST NUMBER	4	5	6
SAMPLING DATE	Aug. 26/86	Aug. 28/86	Sept. 3/86
SAMPLING DURATION, min.	40	40	40
SAMPLE VOLUME AT METER CONDITIONS, m^3	0.6258	0.7048	0.6687
SAMPLE VOLUME AT STANDARD CONDITIONS, dscm*	0.5859	0.6682	0.6238
AVERAGE GAS METER TEMPERATURE, °C	35	30	30
ORIFICE PRESSURE DROP, mm H_2O	25.68	33.71	29.31
STACK STATIC PRESSURE, mm H_2O	-2.54	-2.54	-2.54
AVERAGE STACK GAS TEMPERATURE, °C	716	718	737
AVERAGE STACK GAS VELOCITY, m/s	7.4	8.4	8.0
ISOKINETIC FACTOR, %	104.0	102.3	101.0

*Standard Conditions are 20°C and 760 mm Hg

TABLE 4: SOURCE EMISSION SUMMARY

TEST NUMBER		1	2	3	AVERAGE
STACK GAS COMPOSITION	CO_2	8.0	7.5	7.4	-
DRY BASIS, % BY VOLUME	O_2	11.0	9.5	9.8	-
	CO	0.0	0.0	0.0	-
STACK GAS MOISTURE, % BY VOLUME		12.0	12.5	10.4	-
Ms**, g/g-mole		28.31	28.13	28.38	-
AVERAGE STACK GAS VOLUMETRIC FLOW RATE, dscm/h		663	544	566	591
CONCENTRATION OF PARTICULATE IN THE STACK GAS, g/dscm:	AT STACK CO_2	0.72	0.39	0.42	0.51
	AT 12% CO_2	1.08	0.62	0.68	0.79
EMISSION RATE OF PARTICULATE, kg/h		0.48	0.21	0.24	0.31

** Molecular Weight of the Stack Gas on a Wet Basis

TABLE 4: (CONTINUED)

TEST NUMBER		4	5	6	AVERAGE*
STACK GAS COMPOSITION	CO_2	8.3	11.6	12.0	-
DRY BASIS, % BY VOLUME	O_2	7.3	6.0	5.7	-
	CO	0.0	0.0	0.0	-
STACK GAS MOISTURE, % BY VOLUME		12.1	10.3	7.2	-
Ms**, g/g-mole		28.21	28.85	29.28	-
AVERAGE STACK GAS VOLUMETRIC FLOW RATE, dscm/h		457	531	502	517
CONCENTRATION OF PARTICULATE IN THE STACK GAS, g/dscm:	AT STACK CO_2	0.86	0.09	0.12	0.11
	AT 12% CO_2	1.24	0.09	0.12	0.11
EMISSION RATE OF PARTICULATE, kg/h		0.39	0.05	0.06	0.06

* Tests 5 and 6 only
** Molecular Weight of the Stack Gas on a Wet Basis

DISCUSSION

The concentration of particulate in the stack gas during Test 1 was nearly double that of Tests 2 and 3. Both the pathological and primary chambers were utilized on Test 1 whereas on Tests 2 and 3 only the primary chamber was used. The CO_2 level on all three of the tests was lower than desirable, possibly too much excess air was entering the incinerator which could have entrained particulate in the stack gas that otherwise would have settled out in the bottom of the pathological or primary chambers.

After Test 3 the ignition burner was turned off and only pathological wastes were incinerated as per normal hospital procedure. The low CO_2 levels of Test 4 indicated that the combustion air was then excessive and had to be reduced to a level appropriate for one less gas burner in use. The adjustments made during and following that test produced a 50% increase in the CO_2 level while significantly reducing the particulate matter entrained in the stack gas. As only Tests 5 and 6 reflect these changes they were the only tests used to determine final compliance status.

One further modification that could be partially responsible for the reduction in particulate concentration was a shift in sampling port locations to a site 6.7 m (22.1 ft.) higher up the stack. It was thought that an increase in retention time in the stack would allow more complete oxidation of the gasified and partially combusted components.

CONCLUSION

Tests 1 to 3 indicate an average particulate emission of 0.79 g/dscm when corrected to 12% CO_2 (0.51 g/dscm at average stack CO_2 values), which was in noncompliance with Manitoba Regulation 334/74, Section 3(1) limit of 0.23 g/dscm of flue gas corrected to 12% CO_2.

Tests 5 and 6 indicate an average particulate emission of 0.11 g/dscm at both 12% and average stack CO_2 values. In the latest configuration the incinerator was in compliance with Manitoba Regulation 334/74, Section 3(1).

SELECTED BIBLIOGRAPHY

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2. Reeve, Kevin E. Source Testing For Particulate Emissions From The Pathological Incinerator at Selkirk and District General Hospital, Selkirk, Manitoba. 1985. Wpg., Mb: Manitoba Department of Environment and Workplace Safety and Health, 1986.

3. Standard Reference Methods For Source Testing: Measurement Of Emission Of Particulates From Stationary Sources. Ottawa, Ont: Environment Canada, Environmental Protection Service, 1974 (Report EPS 1-AP-74-1).

APPENDIX A: EQUIPMENT CALIBRATION DATA

DRY GAS METER & ORIFICE METER CALIBRATION SHEET

1/2

Lab. no. 7870

Dry Gas Meter S/N N711C3 — Calibrated re Large Wet Test Meter

Atmospheric Pressure 29.53 in.Hg = 750.1 mm Hg — Calibrated by G. Robertson + K. Reeve

Ambient Temperature 22.8°C — Date 960508

ncmeter rifice ΔH in. H_2O)	W.T.M. Volume V_w ($Ft.^3$)	Dry Gas Meter Reading Initial ($Ft.^3$)	Dry Gas Meter Reading Final ($Ft.^3$)	D.G.M. Volume V_d ($Ft.^3$)	Temperature W.T.M. Tw (°F.)	Temperature W.T.M. Tw (°C.)	Temperature D.G.M. Ti (°F.)	Temperature D.G.M. To (°F.)	Time t (Min.:Sec.)	Time t (Min.)	W.T.M. Manometer Δ m (in. H_2O)	Partial Pressure Ps (mm. Hg)	W.T.M.:D.G.M. Ratio γ (—)	$\sqrt{\quad}$ (—)	Flowrate Q S.C.F.M. ($Ft.^3$/min
.50C	4.0	645.908	649.987	4.079	70.2	21.2	115	94	10:22.34	10.3723	0.40	19.880	1.0065	0.5637	0.3849
.50C	4.0	651.007	655.089	4.082	70.2	21.2	119	84	10:24.95	10.4158	0.30	18.880	1.0096	0.5637	0.3833
.6 ix	4.0	656.107	660.198	4.091	70.2	21.2	120	84	10:26.31	10.4385	0.40	18.880	1.0081	0.5626	0.3824
.C2	4.0	662.273	667.352	4.109	70.2	21.2	114	84	7:14.34	7.2340	0.45	18.880	0.9969	0.8046	0.5507
.C2	4.0	670.435	674.543	4.108	70.2	21.2	114	85	7:14.53	7.2422	0.50	18.880	0.9979	0.8054	0.5514
.C2	4.0	674.577	678.692	4.115	70.2	21.2	114	85	7:16.28	7.2463	0.50	18.880	0.9962	0.8054	0.5510
1.52	5.0	679.718	684.874	5.156	70.2	21.2	116	86	7:24.56	7.4093	0.50	18.880	0.9952	0.9866	0.6746
1.52	5.0	685.903	691.053	5.154	70.2	21.2	116	85	7:24.65	7.4108	0.50	18.880	0.9947	0.9857	0.6727
1.52	5.0	692.055	697.245	5.152	70.2	21.2	116	85	7:24.01	7.4002	0.55	18.880	0.9960	0.9857	0.6722
2.05	6.0	700.338	706.540	6.202	70.2	21.2	116	97	7:47.31	7.7885	0.55	18.880	0.9923	1.1424	0.7698
2.05	6.0	707.477	713.734	6.207	70.2	21.2	116	86	7:47.37	7.7895	0.55	18.880	0.9916	1.1413	0.7683
2.05	6.0	722.083	728.820	6.737	70.2	21.2	117	96	8:27.32	8.4553	0.60	18.880	0.9943	1.1413	0.7669

Linear Regression: Intercept (b) 0.0203

Slope (K) 0.6549

Coefficient of Determination (r^2) 0.9995

$\bar{\gamma}$ = 0.9943 ± 0.0073

ΔH@ = 2.1427

Comments:

#245 Rev. 9/29/95 JF/cm

DRY GAS METER & ORIFICE METER CALIBRATION SHEET

Lab. no. 7870

Dry Gas Meter S/N: N 71103 — Calibrated vs Large Wet Test Meter

Atmospheric Pressure: 29.53 in. H_g or 750.1 mm H_g — Calibrated by: G. R + K.K.

Ambient Temperature: 22.8°C — Date: 860508

Manometer Orifice ΔH (in. H_2O)	W.T.M. Volume Vw ($Ft.^3$)	Dry Gas Meter Reading Initial ($Ft.^3$)	Dry Gas Meter Reading Final ($Ft.^3$)	D.G.M. Volume Vd ($Ft.^3$)	Temperature W.T.M. Tw (°F.)	Temperature W.T.M. Tw (°C.)	Temperature D.G.M. Ti (°F.)	Temperature D.G.M. To (°F.)	Time t (Min.:Sec.)	Time t (Min.)	W.T.M. Manometer Δh (in. H_2O)	Partial Pressure Ps (mm. H_g)	W.T.M.:D.G.M. Ratio γ (—)	$\sqrt{\quad}$ (—)	Flowrate Q.S.C.F.M. Qs ($Ft.^3$/min.)
2.54	6.0	745.921	752.164	6.223	70.0	21.1	116	97	7:02.10	7.0350	0.60	18.765	0.9882	1.2708	0.8515
2.54	6.0	754.226	760.443	6.217	70.0	21.1	116	96	7:02.13	7.0355	0.65	18.765	0.9881	1.2697	0.8498
2.54	6.0	762.525	768.752	6.227	70.0	21.1	116	96	7:02.14	7.0357	0.65	18.765	0.9865	1.2697	0.8498
7.62	7.0	777.055	783.304	7.253	69.8	21.0	115	97	7:32.16	7.5460	0.70	18.650	0.9824	1.3849	0.9255
7.62	7.0	784.403	791.706	7.229	69.8	21.0	115	97	7:33.66	7.5566	0.75	18.650	0.9878	1.3872	0.9247
7.62	7.0	806.005	813.256	7.251	69.8	21.0	115	97	7:33.13	7.5522	0.70	18.650	0.9876	1.3872	0.9246

Linear Regression: Intercept (b) 0.0203

Slope (K) 0.6549

Coefficient of Determination (r^2) 0.9995

$\bar{\gamma}$ = 0.9943 ± 0.0073

$\Delta H@$ = 2.1427

Comments:

#245 Rev. 9/29/83 JF/cm

DRY GAS METER & ORIFICE METER CALIBRATION SHEET Lab No. 13386 ½

Dry Gas Meter S/N Roots 711030

Atmospheric Pressure 29.30 in hg or 744.4 mm hg

Ambient Temperature 22.3°C

Calibrated re Large Wet Test Meter

Calibrated by Jim Prokopovich & Kevin Reese

Date 14 July 86

Orifice ΔH (in. H_2O)	W.T.M. Volume Vw ($Ft.^3$)	Dry Gas Meter Reading Initial ($Ft.^3$)	Dry Gas Meter Reading Final ($Ft.^3$)	D.G.M. Volume Vd ($Ft.^3$)	Temperature W.T.M. Tw (°F.)	Temperature W.T.M. Tw (°C.)	Temperature D.G.M. Ti (°F.)	Temperature D.G.M. To (°F.)	Time t (Min.:Sec.)	Time t (Min.)	W.T.M. Manometer Δm (in. H_2O)	Partial Pressure Ps (mm. Hg)	W.T.M.:D.G.M. Ratio γ (—)	$\sqrt{\quad}$ (—)	Flowrate @ S.T.P. Qm ($Ft.^3$/min.)
.560	5.0	921.370	921.408	5.038	68.5	20.3	64	81	12:08.83	12.1472	0.24	17.864	1.0106	0.5972	0.4104
.560	5.0	927.418	932.484	5.066	68.6	20.3	115	82	12:11.81	12.1968	0.34	17.864	1.0155	0.5978	0.4093
.560	5.0	933.504	938.588	5.104	68.6	20.3	116	84	12:14.55	12.2425	0.36	17.864	1.0106	0.5989	0.4093
.605	5.0	941.162	946.800	5.138	68.6	20.3	112	85	8:53.02	8.8837	0.48	17.864	0.9997	0.8203	0.5642
.605	5.0	947.831	952.981	5.150	68.7	20.4	112	86	8:53.77	8.8962	0.45	17.974	0.9980	0.8210	0.5643
.605	5.0	954.012	959.171	5.159	68.7	20.4	112	86	8:54.54	8.9090	0.38	17.974	0.9964	0.8210	0.5636
.552	6.0	962.268	968.475	6.207	68.8	20.4	114	87	8:50.40	8.8400	0.56	17.974	0.9947	0.9882	0.6816
.554	6.0	967.515	975.720	6.205	68.9	20.5	114	87	8:50.67	8.8445	0.41	18.0855	0.9950	0.9946	0.6812
.553	7.0	976.763	984.007	7.244	68.9	20.5	114	87	10:18.40	10.3067	0.43	18.085	0.9943	0.9914	0.6820
.608	7.0	987.115	994.378	7.263	69.0	20.6	116	87	8:59.99	8.9998	0.70	18.197	0.9911	1.1552	0.7792
.608	7.0	995.414	2.690	7.276	69.0	20.6	117	87	9:00.44	9.0001	0.67	18.197	0.9903	1.1552	0.7792
.608	7.0	3.724	11.005	7.281	69.0	20.6	117	88	9:00.74	9.0001	0.47	18.197	0.9910	1.1562	0.7810

Linear Regression: Intercept (b) 0.0215

Slope (K) 0.6580

Coefficient of Determination (r^2) 0.9994

$\overline{\gamma}$ = 0.9957 ± 0.0083

ΔHG = 2.1226

Comments:

#245 Rev. 9/29/83 JP/cm

DRY GAS METER & ORIFICE METER CALIBRATION SHEET Lab No. 13386 2/2

Dry Gas Meter S/N Bendix 711030

Atmospheric Pressure 29.30 in. hg = 744.4 mm. hg

Ambient Temperature 22.3°C

Calibrated re Large Wet Test Meter

Calibrated by Jim Prichnowich & Kevin Reese

Date 14 July. 86

Manometer Orifice ΔH (in. H_2O)	W.T.M. Volume Vw ($Ft.^3$)	Dry Gas Meter Reading Initial ($Ft.^3$)	Dry Gas Meter Reading Final ($Ft.^3$)	D.G.M. Volume Vd ($Ft.^3$)	Temperature W.T.M. Tw (°F.)	Temperature W.T.M. Tw (°C.)	Temperature D.G.M. Ti (°F.)	Temperature D.G.M. To (°F.)	Time t (Min.:Sec.)	Time t (Min.)	W.T.M. Manometer Δm (in. H_2O)	Partial Pressure Ps (mm. Hg)	W.T.M.:D.G.M. Ratio γ (—)	$\sqrt{\quad}$ (—)	Flowrate @ S.T.P. Qm ($Ft.^3$/min.)
2.53	8.0	39.083	47.404	8.321	69.1	20.6	117	88	9:19.44	9.3240	0.58	18.197	0.9894	1.2744	0.8602
2.53	8.0	48.448	56.773	8.325	69.1	20.6	117	88	9:19.42	9.3237	0.58	18.197	0.9889	1.2744	0.8603
2.53	8.0	57.815	66.134	8.319	69.2	20.7	117	88	9:19.77	9.3295	0.69	18.310	0.9890	1.2744	0.8592
3.07	8.0	69.255	77.569	8.314	69.3	20.7	118	89	8:30.19	8.5032	0.58	18.310	0.9901	1.4042	0.9432
3.08	8.0	79.648	87.965	8.317	69.4	20.8	118	89	8:30.53	8.5088	0.82	18.422	0.9888	1.4065	0.9417
3.06	8.0	89.065	97.324	8.319	69.5	20.8	119	89	8:30.49	8.5082	0.69	18.422	0.9896	1.4019	0.9419

Linear Regression: Intercept (b) _____

Slope (K) _____

Coefficient of Determination (r^2) _____

$\bar{\gamma}$ = _____

ΔH@ = _____

Comments: _____

#245 Rev. 9/29/83 JP/cm

S-TYPE PITOT TUBE CALIBRATION

PROBE SIZE (ft) 5 CALIBRATION # 86-24

PROBE LINER Water Cooled DATE April 10, 1986

PROBE MANUFACTURER _____

TIP SIZE (inches) .500

STACK THERMOCOUPLE ☒ PRESENT

☐ ABSENT

HP 97 INPUT/OUTPUT

Temp	22.4	°C
Bar. Press	29.06	In. Hg
Scale Factor	0.1	

0.46	Δ p (std)	
14.531098		
0.72	Δ p (s-pitot)	
0.797307		
14.534143		

1.32	Δ p (std)	
24.615376		
2.12	Δp(s-pitot)	
0.787104		
24.620534		

0.10	Δ p (std)	
Tunnel Velocity 6.775159	ft/sec	
0.16	Δ p (s-pitot)	
Cp, at this 0.788593	velocity	
Tunnel Velocity 6.776579	(using Cp)	

0.62	Δ p (std)	
16.870010		
1.00	Δ p (s-pitot)	
0.785432		
16.873546		

1.85	Δ p (std)	
29.141061		
2.94	Δp(s-pitot)	
0.791271		
29.147169		

0.20	Δ p (std)	
9.581522		
0.31	Δ p (s-pitot)	
0.801211		
9.583530		

0.80	Δ p (std)	
19.163044		
1.25	Δ p (s-pitot)	
0.798000		
19.167060		

0.790583	Cp (ave)
0.007881	Std. Dev.
8	Deg. of Freedom

0.32	Δ p (std)	
12.119773		
0.53	Δ p (s-pitot)	
0.775086		
12.122313		

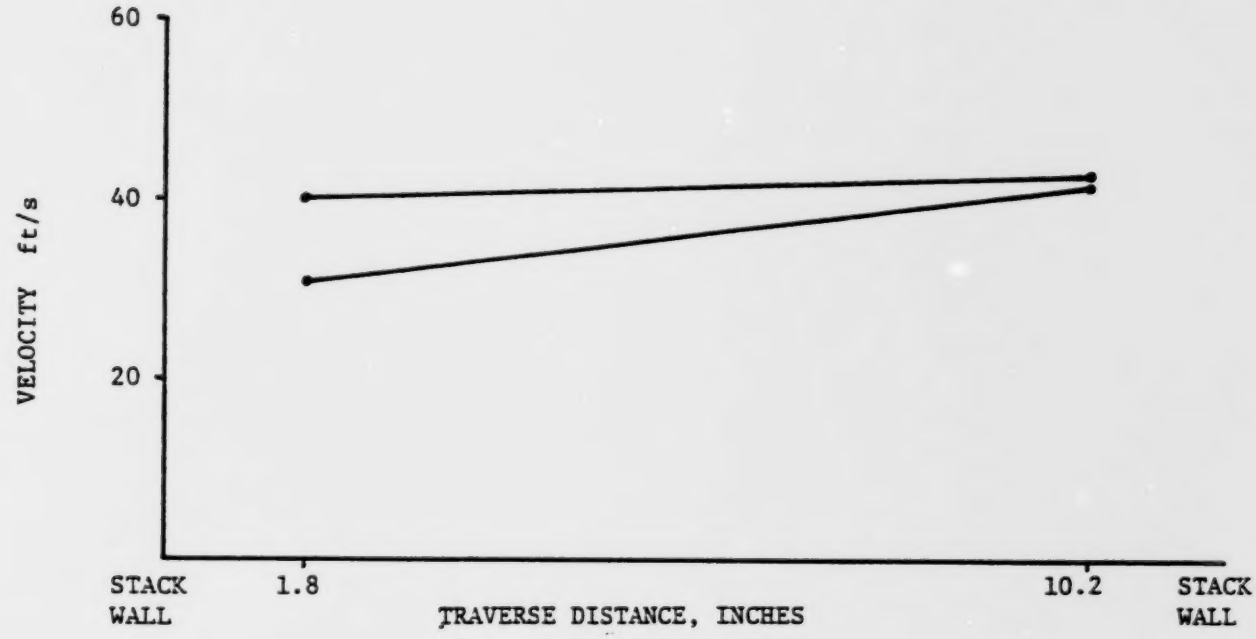
1.12	Δ p (std)	
22.674019		
1.78	Δ p (s-pitot)	
0.791247		
22.678771		

2.306	t .05
0.784526	Low Cp
0.790583	Mean Cp
0.796641	High Cp

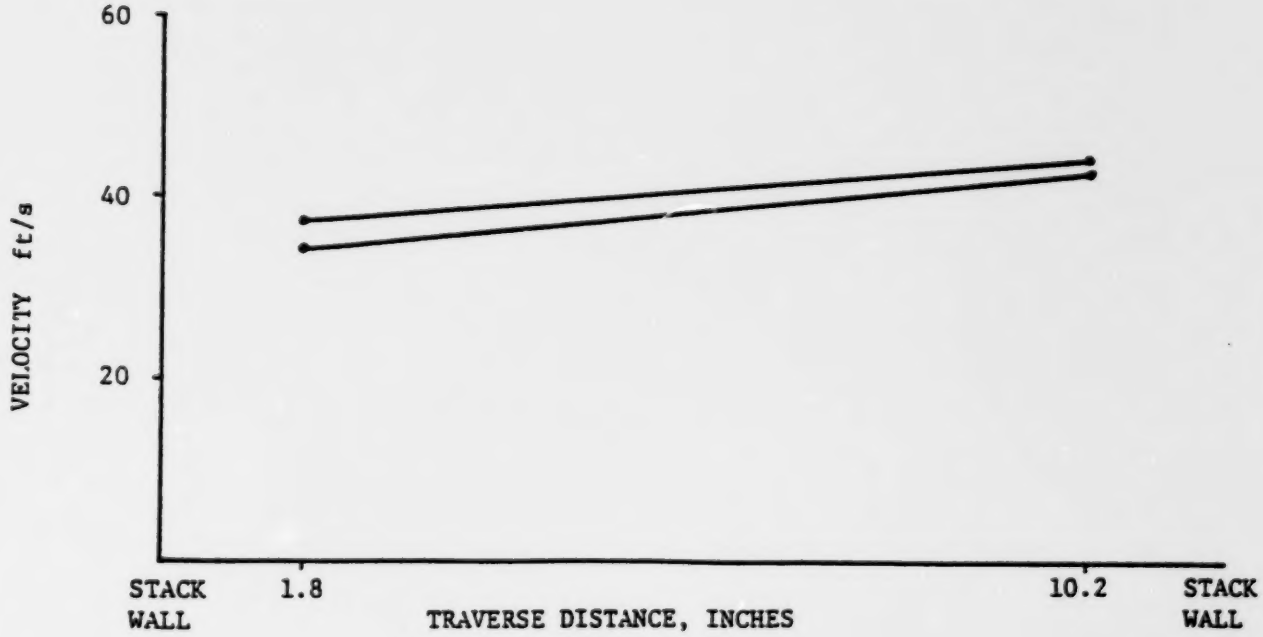
rev. 82-01

APPENDIX B: VELOCITY PROFILES

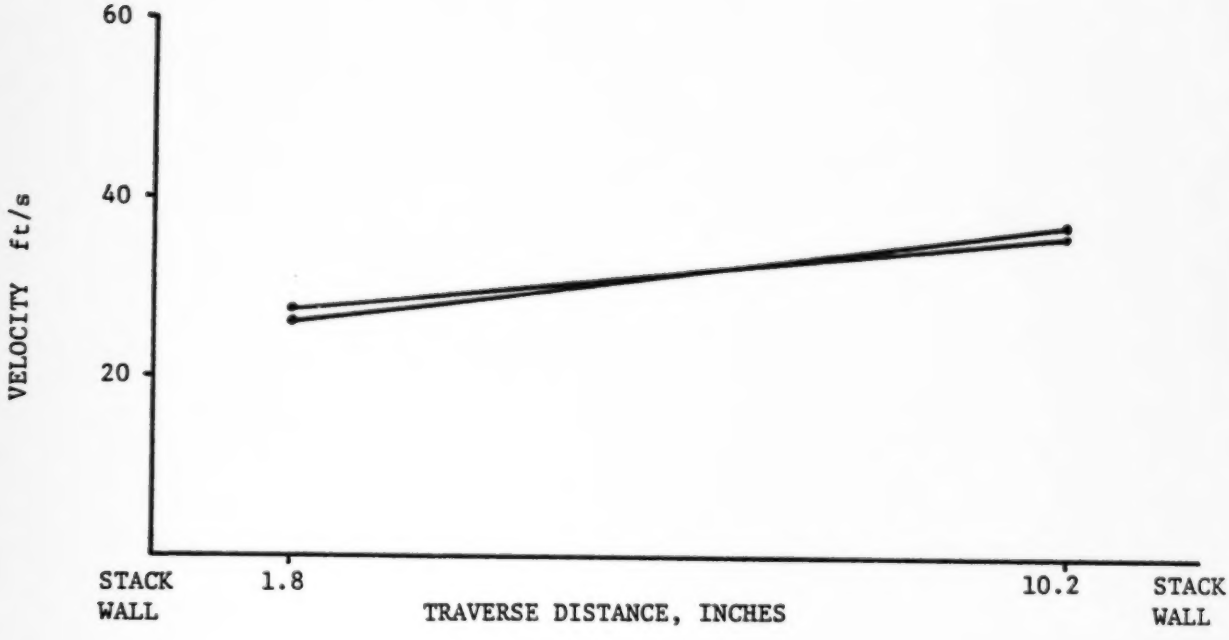
GRAPH 1 . VELOCITY PROFILE OF TEST 1 . SOUTH PORT



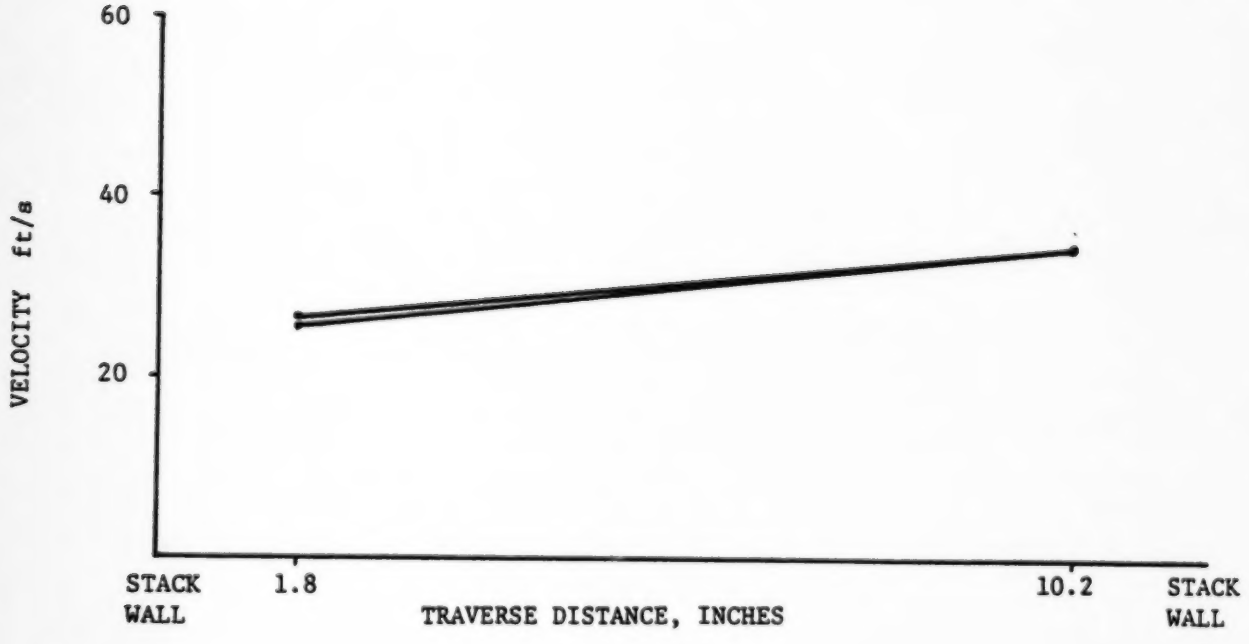
GRAPH 2 . VELOCITY PROFILE OF TEST 1 . WEST PORT



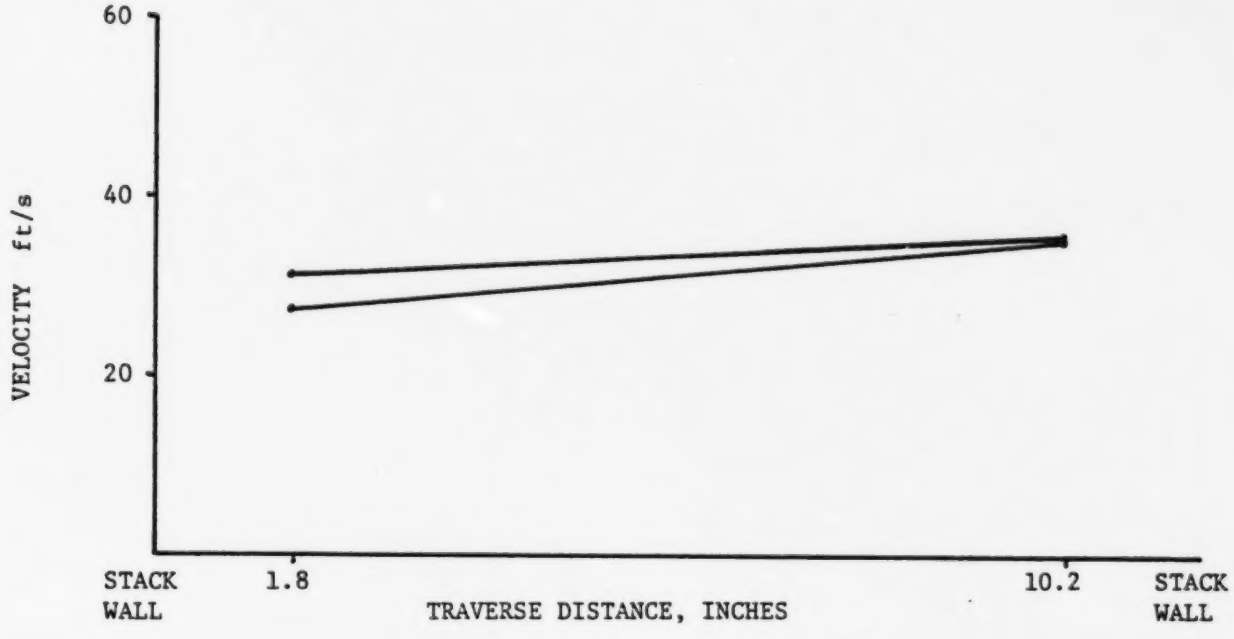
GRAPH 3. VELOCITY PROFILE OF TEST 2. SOUTH PORT



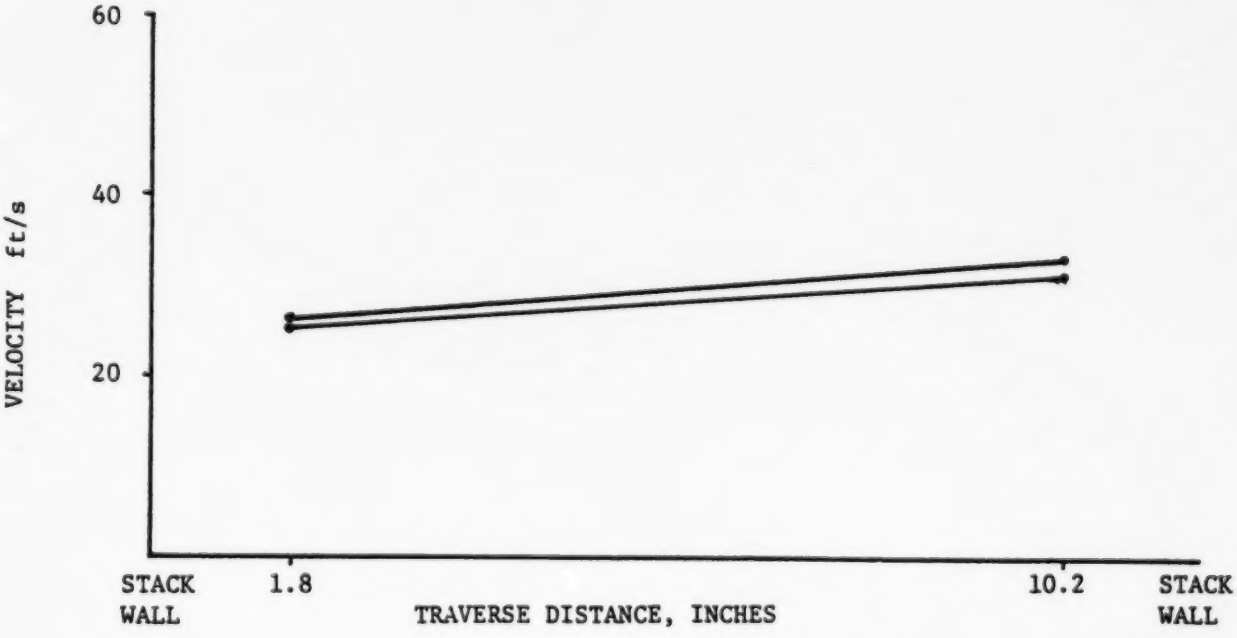
GRAPH 4. VELOCITY PROFILE OF TEST 2. WEST PORT



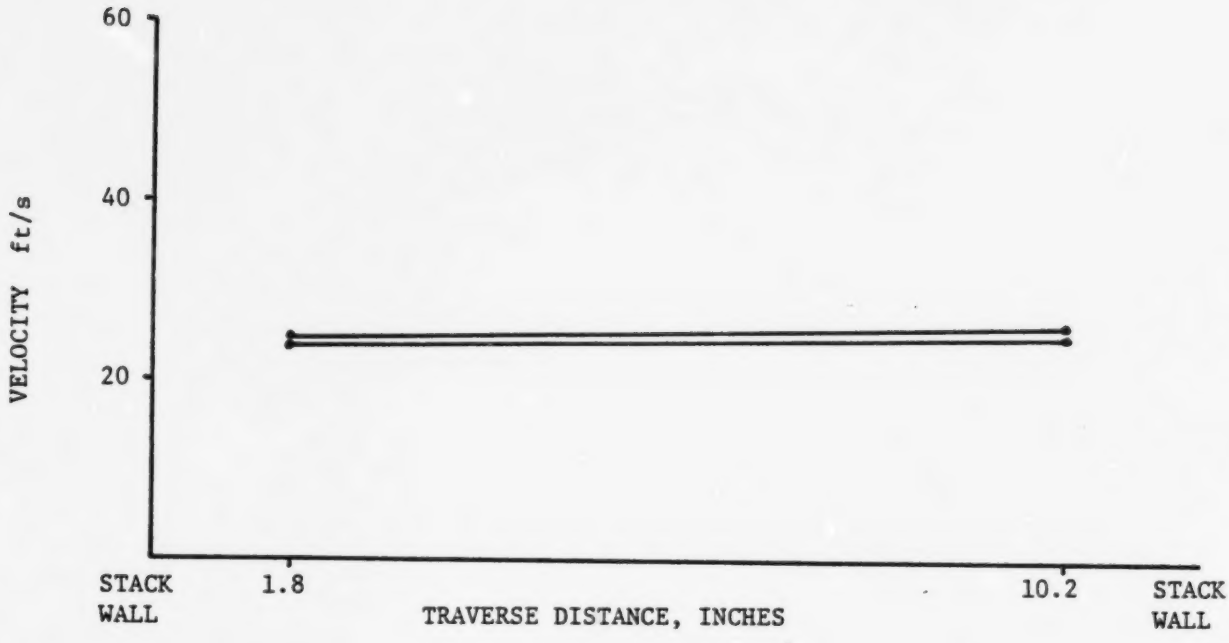
GRAPH 5. VELOCITY PROFILE OF TEST 3. SOUTH PORT



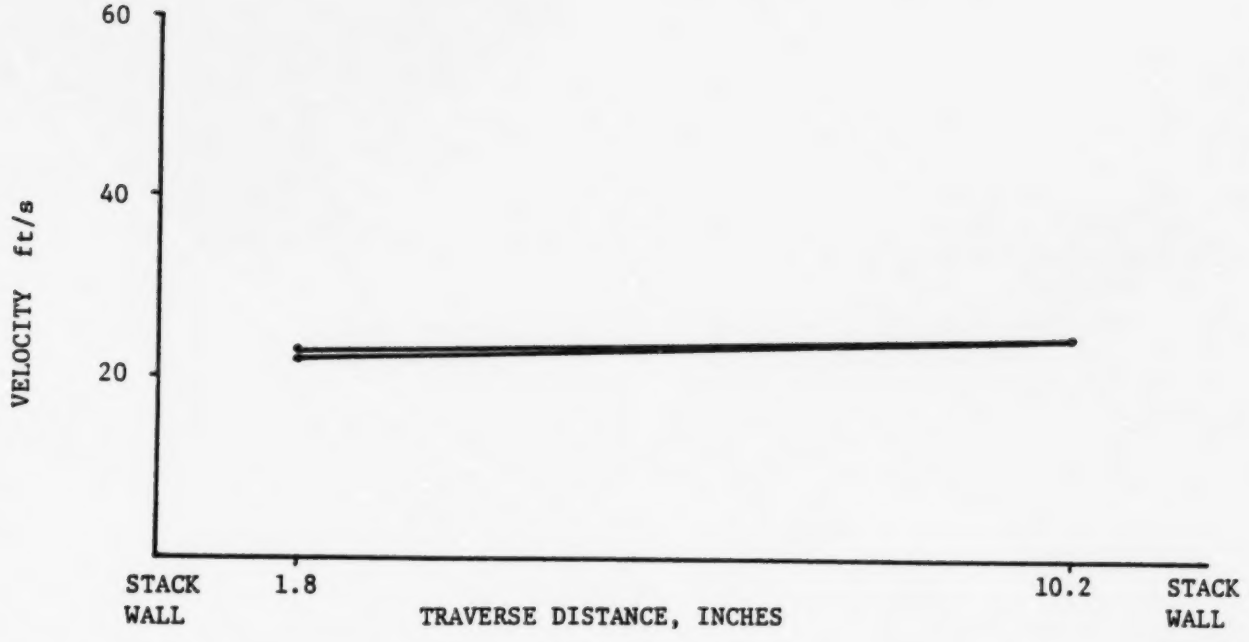
GRAPH 6. VELOCITY PROFILE OF TEST 3. WEST PORT



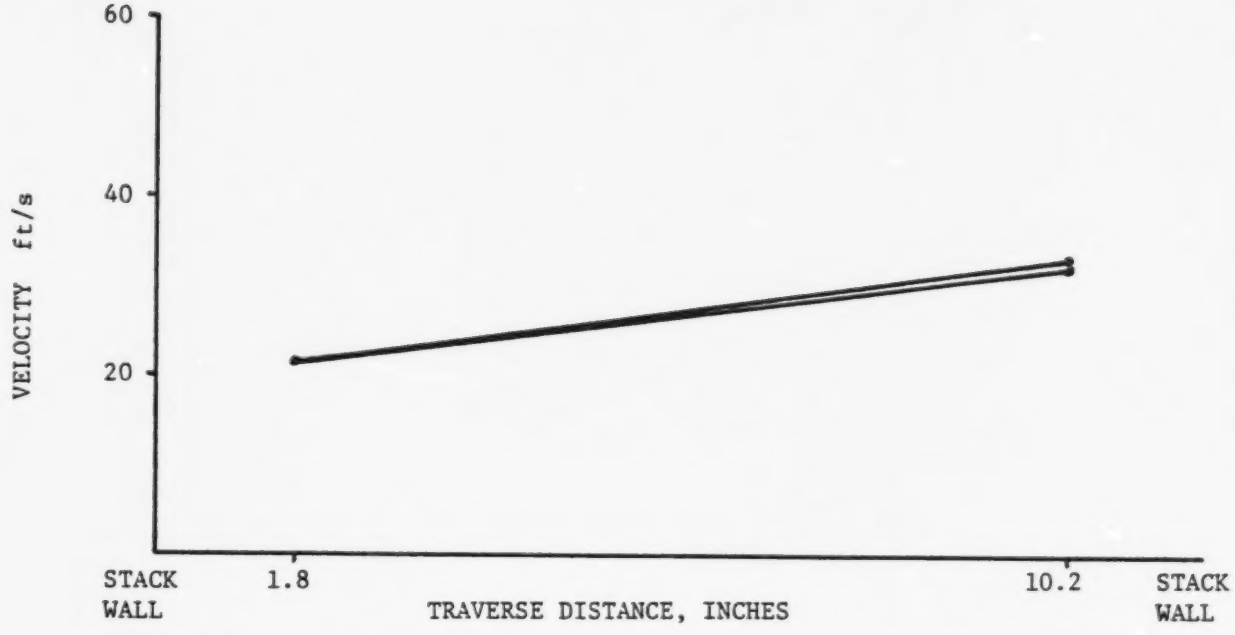
GRAPH 7. VELOCITY PROFILE OF TEST 4. FIRST TRAVERSE



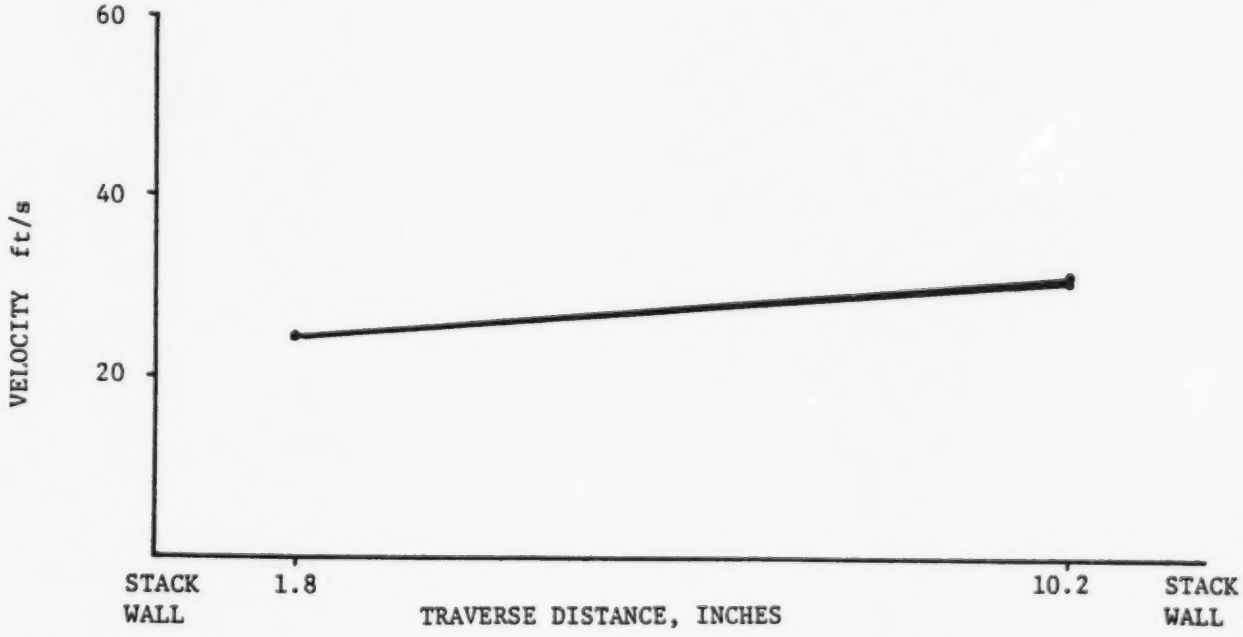
GRAPH 8. VELOCITY PROFILE OF TEST 4. SECOND TRAVERSE



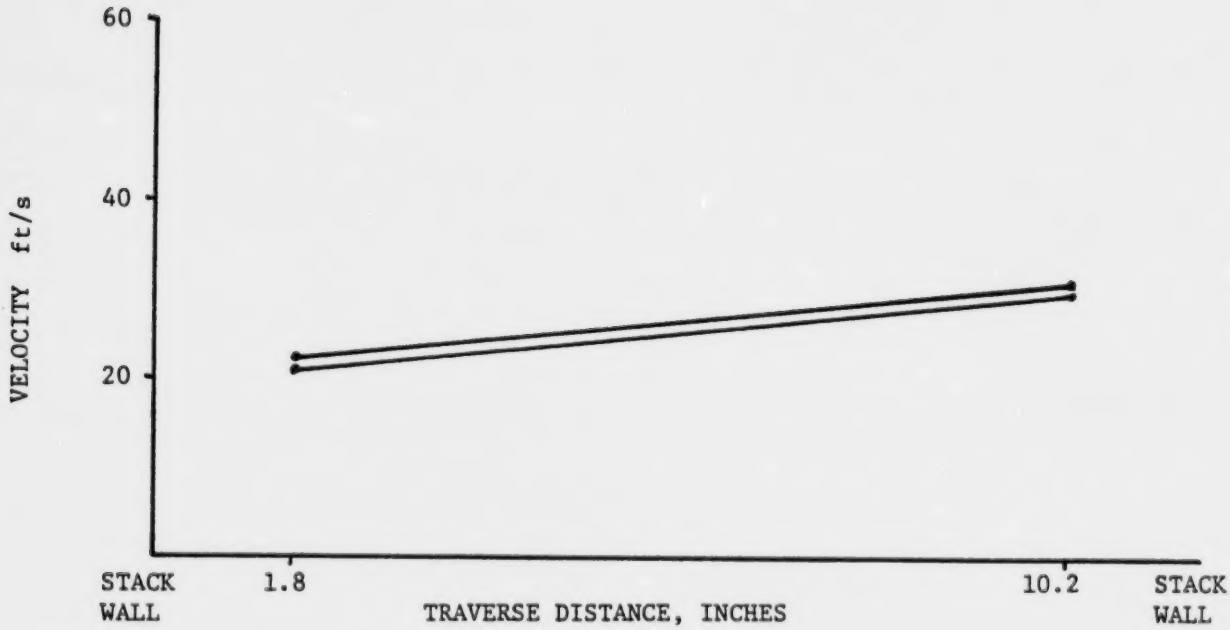
GRAPH 9 . VELOCITY PROFILE OF TEST 5 . FIRST TRAVERSE



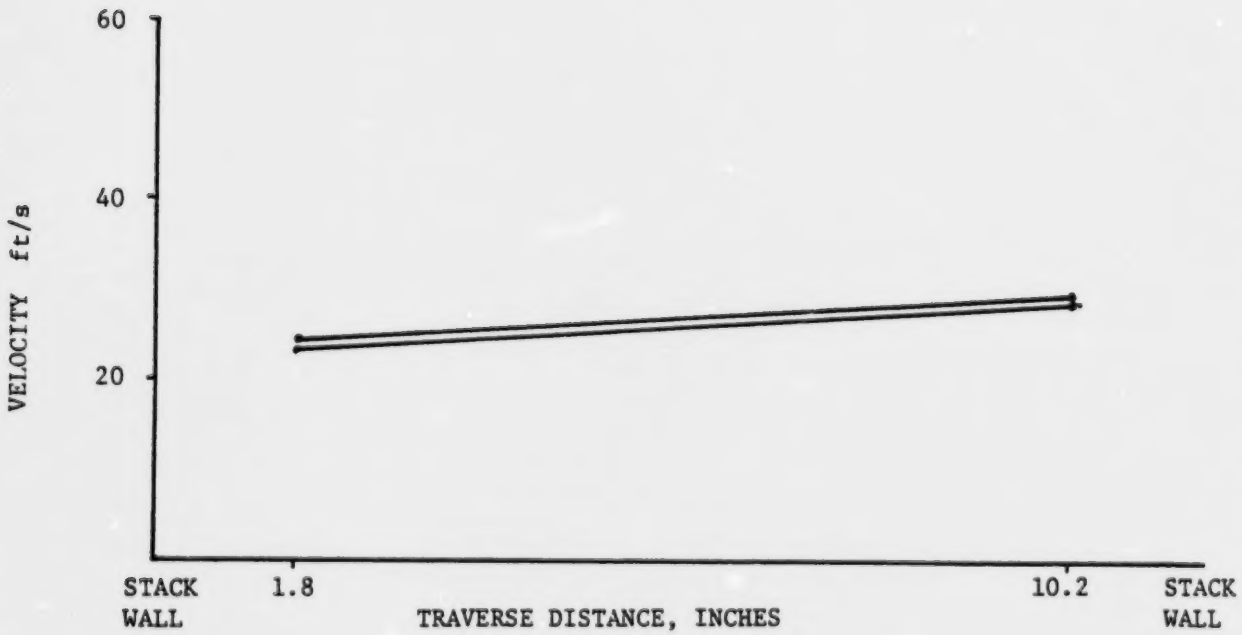
GRAPH 10 . VELOCITY PROFILE OF TEST 5 . SECOND TRAVERSE



GRAPH 11 . VELOCITY PROFILE OF TEST 6 . FIRST TRAVERSE



GRAPH 12 . VELOCITY PROFILE OF TEST 6 . SECOND TRAVERSE



APPENDIX C: FIELD DATA SHEETS

FIELD DATA SHEET

Plant Selkirk and District General Hospital Location 100 General Hospital Drive, Selkirk, Manitoba

Stack Pathological Incinerator Test number 1 Date May 13, 1986

Ambient temperature (°F) 68 Barometric pressure (in. Hg) 28.96 Time 10:50 A.M. to 11:38 A.M.

Nozzle diameter (in.) 0.495 Probe length/type 5 foot/water cooled Stack static pressure (in. H_2O) -0.30

Probe temperature (°F) ave 105 Filter holder temperature (°F) ave 253 Leak check 0.000 CFM @ 15" Hg Vacuum

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. H_2O	Isokinetic factor, %
						Inlet	Outlet			
S-1	0	1682	3.705	0.135	1.84	88	78	48	7	102.9
2	5	1847	3.661	0.145	1.84	98	77	51	7	101.1
2	10	1818	3.657	0.140	1.78	102	78	52	7	101.6
1	15	1563	3.104	0.085	1.22	106	78	55	7	103.8
W-1	20	1716	3.174	0.115	1.56	97	83	50	6	95.0
2	25	1636	3.885	0.165	2.29	105	82	51	10	95.0
2	30	1572	4.194	0.160	2.29	108	82	55	10	101.9
1	35	1516	3.522	0.105	1.55	110	84	58	8	104.0
Average or total	40	1669	28.902	0.131	1.80	-	-	-	-	100.7

FIELD DATA SHEET

Plant Selkirk and District General Hospital Location 100 General Hospital Drive, Selkirk, Manitoba

Stack Pathological Incinerator Test number 2 Date May 15, 1986

Ambient temperature (°F) 68 Barometric pressure (in. Hg) 28.97 Time 10:35 A.M. to 11:21 A.M.

Nozzle diameter (in.) 0.495 Probe length/type 5 foot/water cooled Stack static pressure (in. H_2O) -0.30

Probe temperature (°F) ave 97 Filter holder temperature (°F) ave 294 Leak check 0.001 CFM @ 15" Hg Vacuum

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. H_2O	Isokinetic factor, %
						Inlet	Outlet			
1-1	0	1574	2.408	0.060	0.856	76	70	59	4	100.4
2	5	1705	3.400	0.115	1.519	90	70	60	5	104.4
2	10	1637	3.530	0.115	1.587	92	70	69	6	106.5
1	15	1621	2.615	0.065	0.901	96	71	70	4	103.8
2-1	20	1563	2.550	0.060	0.853	85	74	73	4	104.8
2	25	1535	3.400	0.105	1.552	98	74	80	5	103.7
2	30	1531	3.415	0.105	1.550	102	74	87	5	103.6
1	35	1519	2.720	0.065	0.958	102	75	92	4	104.4
Average or total	40	1586	24.038	0.086	1.222	-	-	-	-	104.0

FIELD DATA SHEET

Plant Selkirk and District General Hospital Location 100 General Hospital Drive, Selkirk, Manitoba

Stack Pathological Incinerator Test number 3 Date May 22, 1986

Ambient temperature (°F) 76 Barometric pressure (in. Hg) 29.18 Time 10:22 A.M. to 11:07 A.M.

Nozzle diameter (in.) 0.495 Probe length/type 5 foot/water cooled Stack static pressure (in. H_2O) -0.30

Probe temperature (°F) ave 94 Filter holder temperature (°F) ave 290 Leak check 0.001 CFM @ 15 " Hg Vacuum

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. H_2O	Isokinetic factor, %
						Inlet	Outlet			
1-1	0	1628	3.068	0.088	1.230	96	83	63	5	101.9
2	5	1574	3.591	0.115	1.700	104	83	55	6	102.3
2	10	1565	3.545	0.113	1.670	106	82	58	6	101.2
1	15	1556	2.850	0.070	1.050	112	84	61	5	102.4
2-1	20	1525	2.635	0.060	0.900	106	88	58	4	101.9
2	25	1559	3.251	0.090	1.360	115	88	56	5	102.9
2	30	1575	3.427	0.100	1.490	116	89	58	5	102.9
1	35	1503	2.858	0.070	1.010	114	89	61	4	104.7
Average or total	40	1561	25.225	0.088	1.30	-	-	-	-	102.5

FIELD DATA SHEET

Plant Selkirk and District General Hospital Location 100 General Hospital Drive, Selkirk, Manitoba

Stack Pathological Incinerator Test number 4 Date August 26, 1986

Ambient temperature (°F) 70 Barometric pressure (in. Hg) 29.38 Time 11:33 A.M. to 12:13 P.M.

Nozzle diameter (in.) 0.495 Probe length/type 5 ft./water cooled Stack static pressure (in. H_2O) -0.10

Probe temperature (°F) ave 80 Filter holder temperature (°F) ave 269 Leak check 0.002 CFM @ 15" Hg Vacuum

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. H_2O	Isokinetic factor, %
						Inlet	Outlet			
1	0	1243	2.876	0.060	1.085	95	91	52	4	106.2
1	5	1344	2.710	0.060	0.995	100	88	52	4	102.7
2	10	1338	2.960	0.070	1.155	105	87	54	4	103.4
2	15	1317	2.840	0.064	1.074	104	86	53	4	103.3
2	20	1323	2.845	0.063	1.055	106	85	53	4	104.6
2	25	1329	2.780	0.062	1.033	103	84	55	4	103.3
1	30	1329	2.530	0.050	0.834	105	84	54	3	104.4
1	35	1340	2.555	0.052	0.857	105	83	54	3	103.8
Average or total	40	1320	22.096	0.060	1.011	-	-	-	-	104.0

FIELD DATA SHEET

Plant Selkirk and District General Hospital Location 100 General Hospital Drive, Selkirk, Manitoba

Stack Pathological Incinerator Test number 5 Date August 28, 1986

Ambient temperature (°F) 60 Barometric pressure (in. Hg) 29.39 Time 10:26 A.M. to 11:06 A.M.

Nozzle diameter (in.) 0.495 Probe length/type 5 ft./water cooled Stack static pressure (in. H_2O) -0.10

Probe temperature (°F) ave 88 Filter holder temperature (°F) ave 262 Leak check 0.001 CFM @ 15" Hg Vacuum

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. H_2O	Isokinetic factor, %
						Inlet	Outlet			
1	0	1254	2.476	0.050	0.852	83	73	57	3	101.7
1	5	1325	2.357	0.048	0.782	92	74	56	3	100.4
2	10	1354	3.655	0.115	1.848	96	74	56	5	101.0
2	15	1347	3.601	0.108	1.739	98	76	58	5	102.0
2	20	1330	3.549	0.103	1.683	101	77	60	5	102.1
2	25	1333	3.550	0.100	1.635	103	79	61	5	103.5
1	30	1330	2.870	0.063	1.035	104	80	62	4	105.0
1	35	1330	2.829	0.063	1.038	107	82	63	4	103.0
Average or total	40	1325	24.887	0.081	1.327	-	-	-	-	102.3

FIELD DATA SHEET

Plant Selkirk and District General Hospital Location 100 General Hospital Drive, Selkirk, Manitoba

Stack Pathological Incinerator Test number 6 Date September 3, 1986

Ambient temperature (°F) 58 Barometric pressure (in. Hg) 28.84 Time 11:10 A.M. to 11:50 A.M.

Nozzle diameter (in.) 0.495 Probe length/type 5 ft/water cooled Stack static pressure (in. H_2O) -0.10

Probe temperature (°F) ave 66 Filter holder temperature (°F) ave 290 Leak check 0.000 CFM @ 15" Hg Vacuum

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. H_2O	Isokinetic factor, %
						Inlet	Outlet			
1	0	1215	2.693	0.055	0.987	81	75	51	4	101.2
1	5	1328	2.335	0.045	0.748	90	74	53	3	99.6
2	10	1421	3.320	0.095	1.499	99	74	55	5	99.3
2	15	1398	3.310	0.089	1.421	102	75	56	5	101.0
2	20	1385	3.260	0.085	1.369	105	76	57	5	101.1
2	25	1371	3.250	0.082	1.334	107	77	59	5	101.9
1	30	1369	2.685	0.055	0.899	107	77	59	4	102.7
1	35	1375	2.758	0.060	0.977	108	78	58	4	100.9
Average or total	40	1358	23.611	0.071	1.154	-	-	-	-	101.0

APPENDIX D: ANALYTICAL REPORT

WM. WARD TECHNICAL SERVICES LABORATORY CHEMICAL ANALYSIS FORM II

SUBMITTER: KEVIN REEVE
LOCATION: SELKIRK DISTRICT GENERAL HOSPITAL
REPORT TO: KEVIN REEVE - AIR POLLUTION CONTROL - BLDG. 2, 139 TOKEDO ER-1

SAMPLE - ID
From: Y 86 Sequent 08414416
To: Y 86 Sequent 08414448

Date Sampled: Y 86 M 05 D 13
Date Received: Y 86 M 05 D 16

L – Less than
G – Greater than

Sample Number	Identification or Comments	Parameter	L/G	Value	Units	Date Analysed
08446	PROBE WASHINGS AND GLASSWARE BEFORE FILTER	TSP		0.1458.59	g	86 05 21
08447	IMPINGER 1 AND 2 CONTENTS	TSP		0.0183	g	86 05 21
08448	FILTER # 491	TSP		0.0431	g	86 05 21

RECEIVED
JUN 24 1986
EMD

Date 86 06 19

Chemist Signature

W.M. WARD TECHNICAL SERVICES LABORATORY CHEMICAL ANALYSIS FORM II

SUBMITTER: KEVEN REEVE
LOCATION: SELKIRK DISTRICT GENERAL HOSPITAL
REPORT TO: KEVEN REEVE – AIR POLLUTION – RDBC 2, 139 TYKE RD, ER-1

SAMPLE – ID
From: Y 8 | Sequent 1 8 4 4 9
To: Y 8 | Sequent 1 8 5 1 1

L – Less than
G – Greater than

Date Sampled: Y 8 | M 05 | D 15
Date Received: Y 8 | M 05 | D 16

Sample Number	Identification or Comments	Parameter	L/G	Value	Units	Date Analysed
08449	PRE-WASHINGS AND GLASSWARE BEFORE FILTER	TSP		0.1182	g	86529
08450	IMPINGER 1 AND 2 CONTENTS	TSP		0.0133	g	1 1 5 2 1
08451	FILTER # 496	TSP		0.0615	g	1 1 5 2 1

RECEIVED
JUN 24 1988
EMD

Date 86 06 19

Chemist Signature

W.M. WARD TECHNICAL SERVICES LABORATORY CHEMICAL ANALYSIS FORM II

SUBMITTER: K. REEVE
LOCATION: SELKIRK AND DISTRICT GENERAL HOSPITAL
REPORT TO: K. REEVE - FOC
ER-1

SAMPLE – ID From: Y 86, Sequent 018951 7 To: Y 86, Sequent 018951 9

L – Less than
G – Greater than

Date Sampled: Y 86, M 05, D 27
Date Received: Y 86, M 05, D 28

Sample Number	Identification or Comments	Parameter	L/G	Value	Units	Date Analysed
08957	BOTTLE #1 - RINSE WASHINGS = GLASSWARE BEFORE FILTER	TSP		0.2660	g	86 05 28
08958	BOTTLE #2 - IMPINGER 1 AND 2 CONTENTS	TSP		0.0075	g	86 05 28
08959	FILTER # 492 - SELKIRK GENERAL HOSP	TSP		0.0106	g	86 05 28

Date 86 05 29

Chemist Signature

WM. WARD TECHNICAL SERVICES LABORATORY CHEMICAL ANALYSIS FORM II

SUBMITTER: K. REEVE
LOCATION: SELKIRK GENERAL HOSPITAL — TEST # 4
REPORT TO: K. REEVE — P.A.C.
ER-1

SAMPLE – ID
From: Y 86 Sequent 172168
To: Y 86 Sequent 172170

L – Less than
G – Greater than

Date Sampled: Y 86 M 08 D 26
Date Received: Y 86 M 08 D 29

Sample Number	Identification or Comments	Parameter	L/G	Value	Units	Date Analysed
17268	BOTTLE #1	TSP		0.1482	g	86.09.04
17269	BOTTLE #2	TSP		0.0030	g	86.09.04
17270	31 FILTER # 498	TSP		0.0223	g	86.09.04

Date: Sept 2/86
Chemist Signature:

WM. WARD TECHNICAL SERVICES LABORATORY CHEMICAL ANALYSIS FORM II

SUBMITTER: K. REEVE
LOCATION: SELKIRK GENERAL HOSPITAL - TEST #5
REPORT TO: K. REEVE - E.C.C.
ER-1

From SAMPLE - ID: Y 86 Sequent 17127 1
To: Y 86 Sequent 17127 3

L – Less than
G – Greater than

Date Sampled: Y 86 M 08 D 28
Date Received: Y 86 M 08 D 29

Sample Number	Identification or Comments	Parameter	L/G	Value	Units	Date Analysed
17271	1) BOTTLE #1	TSP		0.0447	g	86.09.07
17272	2) BOTTLE #2	TSP		0.0013	g	86.09.07
17273	3) FILTER #499	TSP		0.0164	g	86.09.07

Date 86/09/26

Chemist Signature

MO 2832(a) 08/84 2 SM

W.M. WARD TECHNICAL SERVICES LABORATORY CHEMICAL ANALYSIS FORM II

SUBMITTER:	K. REEVE
LOCATION:	SELKIRK GEN HOSP – TEST #6
REPORT TO:	K. REEVE
	ER-1

SAMPLE – ID

From Y 86 Sequent 17567

To Y 86 Sequent 17569

Date Sampled Y 86 M 09 D 03

Date Received Y 86 M 09 D 04

L – Less then
G – Greater then

Sample Number	Identification or Comments	Parameter	L/G	Value	Units	Date Analysed
17567	BOTTLE # 1	TSP		0.0502	g	86.09.09
17568	BOTTLE # 2	TSP		0.0071	g	86.09.09
17569	FILTER # 500	TSP		0.0257	g	86.09.10

Date 86 09 22

Chemist Signature